Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Environmental Sciences 11 (2011) 1407 – 1411

Procedia Environmental Sciences

Effects of Vacuum on Sterilizing Rate in Medical Waste Steam Treatment Process

JIN Dengchao[1,2] ,BAO Zhenbo[1,2] ,YU Xinping[1,2]

[1]*Department of Mechanic and Electronic Engineering,Tianjin Agricultural University Tianjin ,China,300384*

[2] *China-Japan (Tianjin) Collaborative Research Center for the Rural Environment and Resource Tianjin ,China,300384*

E-mail:Dengchao.jin@gmail.com, E-mail:baozhenbo@sohu.com

Abstract

The effects of vacuum on sterilizing rate and heat transfer were tested in the medical waste steam treatment process using the modern medical waste sterilizer . Both the heat penetration and biological indicator tests were performed under different parameters. The results indicated that the vacuum degree has influence on both heat penetration and sterilizing effect. Higher vacuum degree and more vacuum times will cause higher temperature at the same pressure in sterilizer chamber, which will result stronger heat penetration and better sterilizing rate.

*Keywords:*Medical waste, Steam autoclave treatment, fluctuation vacuum, Heat penetrability, sterilizing effec

1. Introduction

Medical waste is hazardous because of its contagious nature. More and more attentions were paid on how to manage and dispose it[1]. Because of its high investment and cost, incineration technology has been gradually replaced by non-incineration process. Steam treatment technology is one example of the non-incineration process. The principle of steam treatment process is moisture-heat sterilizing, the heat of steam will cause protein in the microbes to denaturalize, solidify and carbonize , which will eliminate the infection of pathogenic bacteria[2,3]， How quickly the steam heat can transport and penetrate through medical waste and how well it can be distributed in sterilizing chamber becomes critical in this process. The air remnant in the chamber is an important factor affecting the heat transfer. Therefore, removing the air by vacuum is the effective method to improve the heat transfer and penetrating performance[3,4]. In

doi:10.1016/j.proenv.2011.12.211

this paper, modern medical waste sterilizer was used to verify the effects of vacuum on sterilizing rate and heat transfer.

2. Experimental devices and method

2.1.Experimental devices

The basic procedure in medical steam treatment technology is described as below. First, medical waste was placed into sterilizer, and then the door was closed and sealed. Secondly vacuum pump was used to draw the air out of the chamber. Finally the steam was injected into the chamber to make sure the pressure will reach the setting value. After this, the second vacuuming and steam injection may start over again. ,. This fluctuation vacuum process may be repeated many times. At last the temperature was kept the same over the sterilizing time in order to assure the fully disinfection[4,5]..

Picture 1 is the experimental sterilizer; it can be operated manually and automatically. The parameters such as vacuum, vacuum times, pressure, sterilizing temperature and sterilizing time can be set based on the requirement through the control panel. There is also pressure, temperature indicator and record system in this equipment.

Figure 1. Medical waste sterilizer

Figure 2. Biological indicator tube

2.2.Sample and testing method

Picture 2 is biological test tubes which were produced by 3M Company[6,7]. Biological indicator stearothermophilus (ATCC7953) and its culture-medium were separately placed in the tube. After the biological indicator tube was sterilized, it will be broken up and contact the culture-medium. It will be kept long enough at the constant temperature to test if the sterilizing will meet the requirements by watching the color change. If the sterilizing was good enough, the color would kept to be purple; otherwise the color would change to be yellow.

Steam incubator produced by 3M company in the U.S, (Fig, 3) can be used together with Biological test tube and provided the condition to culture biological indicator to show whether it is completely sterilized

B-D test pack and pattern (Fig.4) is a special material used to examine the penetration degree in moist sterilization process by observing the color of test pattern sheet[6,7]. If the penetration was completed, the pattern would fully change to be black from yellow, otherwise it would not or only portly become black.

Figure 3. Biological steam incubator

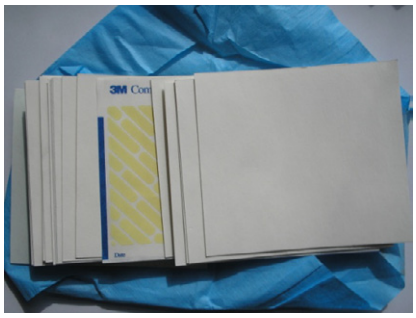

Figure 4. B-D test pack and pattern

2.3.Experiment

The chamber temperature was measured and recorded under the same pressure but different vacuum degrees and vacuuming times. The heat penetration and sterilization performance were recorded accordingly.

3. experimental results and analyses

3.1.Vacuum effect on chamber temperature

After the chamber reached the setting pressure (0.2 Mpa), the temperature at different testing points were obtained under various vacuum degrees and vacuum times. See below Table.1.

TABLE 1 CHAMBER TEMPERATURE IN DIFFERENT VACUUM

	Vacuum for one times					*Vacuum for three times*
Vacuum (-Mpa)	0.00	0.02	0.04	0.06	0.08	0.08
point1（℃）	93.9	99.9	106.2	111.3	116.5	120.0
poin2（℃）	94.2	100.1	105.9	111.0	116.0	120.3
poin3（℃）	93.8	99.7	105.8	110.7	115.7	119.6
poin4（℃）	94.1	100.4	106.2	111.1	116.0	120.2
average（℃）	94	100	106	111	116	120

It can be discovered that the higher vacuum degree and more vacuuming times lead to the higher temperature. This may be from the fact that the higher vacuum degree and more vacuuming times result in little air remnant. The air remnant affected the nature of the mixed gas, which resulted the mixed gas temperature was lower than the pure saturation steam. This test result was consistent with what found from the literatures[8].

3.2.The effect of vacuum on heat penetration

When the sterilizing temperature was 120 ℃ and the sterilizing time was 5min, the penetration performance in various vacuum degrees and vacuuming times were shown in Fig.5. It can be found that higher vacuum degrees and more vacuuming times lead to the larger area color changes, which indicated that high vacuum and more vacuum times could strengthen the heat penetration in chamber.

The saturated steam could quickly condense and provide large heat when it is cooled, at the same time its volume would shrink to 1/1600. This would lead to negative pressure which would help the steam molecule to transfer and stimulate the heat penetration. The air, however, cannot bring the negative pressure in that temperature for its low condensation point. Therefore the air had more influence on the mixed gas. More air remnant lead to less steam contained in mixed gas and less negative pressure would form. Furthermore, the mixed gas gave less heat. All of these factors reduced the heat penetration.

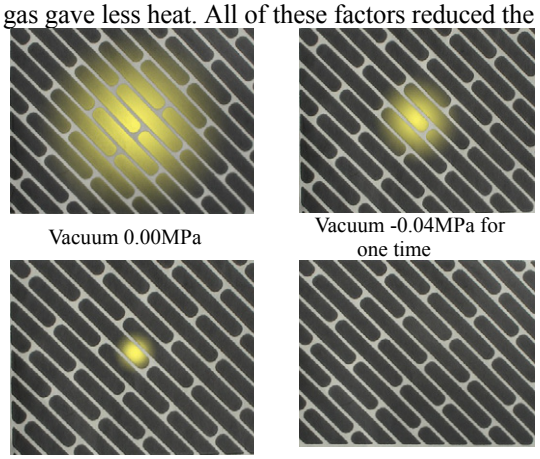

Figure 5. Heat penetrability in different vacuum(120℃，5min)

3.3.Vacuum effect on sterilizing performance

Three 200mmx200mmx100mm cloth bags containing two biological indicator tubes in its centre were putted into the sterilizer chamber. Under the temperature as 120 ℃ and sterilizing time as 20min, the

sterilizing result at different vacuum degrees and vacuum times were shown in Tab.2. It can be found that as the vacuum degree and times increased, the sterilizing rate would be increased as well.

Theoretically, when material was sterilized, the contaminated bacteria would be killed through protein solidification or carbonization. The critical factors influencing sterilizing rate were temperature and time. The air would affect the nature of mixed gas and the heat transfer. At the same time it will affect the time for the heat to reach the material center. Even if the temperature in the chamber was the same, different vacuum degrees and vacuum times would lead to various air remnants, which will considerably affect the sterilizing performance.

TABLE2 STERILIZING EFFECT IN DIFFERENT VACUUM (121℃，20MIN)

	Vacuum for one time					***Vacuum for three times***
Vacuum	0.00 MPa	0.02 MPa	0.04 MPa	0.06 MPa	0.08 MPa	0.06 MPa
Tube 1	-	-	-	-	+	+
Tube 2	-	-	-	-	-	+

Note: + sterilized; -not sterilized

4. Conclusion

(1)Higher vacuum degree and more vacuuming times will lead to higher temperature under the same pressure in sterilizer chamber.

(2)Higher vacuum degree and more vacuuming times will result in stronger heat penetration and better sterilizing rate.

(3)The vacuum degrees have influence both on heat transfer and sterilizing effect.

5. Acknowledgment

This study was both supported by ministry of science and technology of China (project No. 10C26211200155) and Tianjin municipal science and technology commission (project No. 10ZXCXSH03900 and 09ZHXHNC06800).

References

[1] L.F.Diaz，L.L. Eggerth, Sh. Enkhtsetseg. “Characteristics of healthcare wastes”, Waste Management ,vol 28,. 2008, pp.1219－1226

[2] Gai Ruoyan,Xu Lingzhong, Li Huijuan, “Investigation of health care waste management in Binzhou District”, China , Waste Management , vol 30,2010,pp. 246－250.

[3] L.F.Diaz, G.M.Savage, L.L.Eggerth. “Alternatives for the treatment and disposal of healthcare wastes in developing countries” , Waste Management,vol 25: 2005, pp. 626-637.

[4] Health Care Without Harm. “Non-Incineration Medical Waste Treatment Technologies-A Resource for Hospital Administrators, Facility Managers, Health Care Professionals, Environmental Advocates and Community Members’. 2001, 17-35.

a) www.noharm.org/us/medicalwaste/alternatives

[5] WEI Zhao, Ester van der Voet, Gjalt Huppes. “Comparative life cycle assessments of incineration and non-incineration treatments for medical waste”,.International Journal Life Cycle Assess vol 14, 2009,pp.114–121.

[6] Technical Specification for Steam-based Centralized Treatment Engineering on Medical Waste(HJ/T276-2006)[S], China EPA,Beijing,2006:24-25(in chinese).

[7] Technical Standard For disinfection[S],Ministry of Health of China.Beijing,2002: 205-206 205-206 (Ch).

[8] TANG Xinyun,ZHANG Ming,ZHAO Haiquan, “The temperature and pressure Relationship of Mixed gases in Autocave”, Acta Microbiologica Sinica, vol 30(3) ,2003,pp.14-17(in chinese).